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A RESUMÉ OF REGION 4 AIR POLLUTION DETECTION ACTIVITIES IN THE VICINITY OF THE NAVAJO GENERATING STATION PAGE, ARIZONA 1970-1976

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A RÉSUMÉ OF REGION 4 AIR POLLUTION DETECTION ACTIVITIES IN THE VICINITY OF THE NAVAJO GENERATING STATION
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Introduction. Early in 1970 requests for assistance were received from the Superintendent of the Glen Canyon National Recreation Area (GCNRA) and from the Director, Kanab District, BLM. They were both concerned about and desired information on the possible detrimental effects of airborne emissions from the soon to be constructed coal fired Navajo Generating Station. Their concerns were primarily about the possible adverse effects of SO_2 emissions upon vegetation in and adjacent to the Glen Canyon NRA. The Navajo plant is four miles east of Page, Arizona. Water for the plant is drawn from nearby Lake Powell. Coal is shipped to the plant via an 80-mile long railroad from Black Mesa on the Navajo Indian Reservation.

Topography. A study of topographic maps of the area shows that the Navajo plant is roughly in the center of a large basin approximately 2,288 square miles in area. The plant elevation is 4,200 feet. The elevations on the northern perimeter of the basin range from 6,000 feet to 7,000 feet with occasional points to 7,500 feet. The Kaiparowits Plateau forms a 50-mile long barrier of 7,000 feet plus elevation to the north and east of the plant. The basin has only two natural outlets. One is up the Colorado River between Navajo Mountain and the southeast end of the Kaiparowits Plateau. The other is down the Colorado through Marble Canyon into Grand Canyon. Most of the land around Lake Powell is severely dissected by canyons, with mesa top elevations up to 7,000 feet, and canyon walls dropping precipitously to the lake.

Meteorology. From the point of view of air pollution buildup, the most important feature of the meteorology of the Four Corners Region are the extended periods of air stagnation. In the winter a high pressure is located almost constantly over this area. Five years of meteorological data analyzed by Holzworth 1/ indicate this clearly. For example, in this five-year period episodes of stagnation in the Four Corners area resulted in high meteorological potential for air pollution for a mixing height of 500 meters twice for a total of 13 days; for a mixing height of 1,000 meters twice for a total of 17 days; and for a mixing height of 1,500 meters 25 times for a total of 192 days. Wind speed within the inversion was equal to or less than 6.0 meters/second. Mixing height indicates the height of the inversion above ground level. The lower the mixing height the greater the air pollution potential.

1/ Mixing Heights, Wind Speeds, and Potential for Urban Air pollution throughout the Contiguous United States. George C. Holzworth. EPA Publication AP-101. 1972

Wind direction determines the dispersion of emissions from a point source such as the Navajo Plant. Dames and Moore, Consulting Meteorologists, plotted wind direction at Winslow, Arizona, and reported that winds at 500 feet blew from the southern quadrant 28% of the time. If winds blowing from the SW to west are included (225°-270°, 23% of the time) the sum of percentage of time the winds are blowing from SE thru W (135°-270°) is 51%.

Air Quality Sampling. It was necessary to measure the sulfur content of the air before plant operation began in order to detect any increases in airborne SO_2 following the plant going "on line". The devices used to check this were sulfation plates. Briefly, these are prepared plastic petri dishes containing a lead dioxide paste in a matrix. Upon being exposed to sulfur, a chemical reaction takes place converting lead dioxide to lead sulfate. This lead sulfate is quantitatively analyzed by a standard procedure, the end result being a reading of sulfur in parts per million (ppm). A network of these plates was established up and down Lake Powell on Glen Canyon NRA and Bureau of Land Management lands (see Appendix A for locations). The sulfation plate monitoring system was maintained for a year in each location with individual plates being replaced at two-month intervals. Analysis of exposed plates was done at the University of Utah. No sulfur was found in the air around Lake Powell by this method. A much more sensitive test conducted by University of Utah personnel revealed 0.002 ppm sulfur which is in the range generally considered to be natural background levels.

During the month of April 1975, the State of Utah established a permanent air quality monitoring station at Wahweap. During June 1975 a similar station was established at Bullfrog Basin. Bendix flame photo-metric SO_2 monitors were installed at each location to monitor SO_2 levels.

Vegetation Studies. It was also necessary to know what effect the present and future levels of sulfur might have upon vegetation. In order to be able to recognize this effect, it was necessary to become familiar with the present condition of vegetation in the area. A permanent file of closeup photographs of representative vegetation in selected areas was developed. Five permanent vegetation plots have been established at various distances from the plant. Locations are noted in Appendix B and on the accompanying map. We now have two volumes of closeup photographs and some general views of vegetation from the Lake Powell area (see Appendix D). This vegetation assessment work has been in progress since 1970 and will continue until it is clear what effect emissions from the Navajo Plant are having on vegetation in this area.

Results. The first unit of the Navajo plant went "on line" in May 1974. Examinations of vegetation on the plots in June and September 1974 revealed no damage that could be attributed to SO_2 emissions. Further examinations in May 1975 and 1976 failed to show any vegetation effects of sulfur. All three generating units were functioning before and during the 1976 examinations.

Highest hourly average SO_2 concentartion measures at the Wahweap Air Quality Monitoring Station in 1975 was .06 ppm for one hour on October 9. For 1976, at the same location, the highest hourly average was .06 ppm on August 29.

At Bullfrog Basin the highest hourly average was .03 ppm on November 2, 1975. Highest hourly average in 1976 was .03 ppm on April 1.

Conclusions. Concentrations of SO_2 as measured by the State of Utah Air Quality monitors is below any recognized level which can cause damage. This statement is borne out of total lack of vegetation effects. In addition to the low levels of SO_2 there are plant physiological and meteorological factors which may further ameliorate the effects of SO_2 upon vegetation. In this dry desert region the stomates are almost always closed to conserve water. Desert plants are extremely hardy and can survive droughts, alkaline soils, extremely high temperatures, and blowing sand.

Inversions, which could concentrate the emissions from the generating station, occur principally during the winter when the vegetation is dormant. Thermal updrafts occur during hot weather, causing mixing of the SO_2 with unpolluted air. These same thermals may carry the SO_2 to high elevations where high altitude winds could carry the gases to the east. We can only conclude, when all the factors are evaluated, that the probability of damage by SO_2 to the vegetation in the Lake Powell area is low.

The May 1976 examinations were carried out in the company of Glen Canyon NRA Chief Ranger Richard Ward. Mr. Ward was shown all plot locations and took part in the examination of the vegetation. The total absence of damaging effects by SO_2 was pointed out to him. After discussing possible future effects and our continuing detection and evaluation responsibility to the Glen Canyon NRA, we mutually agreed to curtail further examinations.

Mr. Morgan Jensen, Director of the Cedar City District, Bureau of Land Management, also agreed to the termination of the vegetation examinations. He is also aware of our responsibility to the Bureau of Land Management in the field of insect and disease detection, evaluation and control.

APPENDIX A

Sulfation Plate Locations[1/]

Station Number	Location	
BLM 1	Glen Canyon City	NE¼NW¼NE¼ Sec. 9, T. 43 S., R. 2 E.
BLM 2	Warm Creek	NE¼SW¼SW¼ Sec. 33, T. 42 S., R. 4 E.
BLM 3	Smoky Mountain	NE¼NW¼NW¼SW¼ Sec. 31, T. 40 S., R. 4 E.
BLM 4	Cow Camp	E¼ corner of NW¼NW¼NE¼, Sec. 28, T. 39 S., R. 2 E.
BLM 5	Resource Area Office Escalante, Utah	SW¼NE¼NW¼, Sec. 19, T. 36 S., R. 2 E.
BLM 6	Upper Valley (southwest of Escalante)	SW¼NE¼NW¼ Sec. 19, T. 36 S., R. 1 E.

GC 1	At confluence of San Juan and Colorado Rivers
2	Floating Marina, Rainbow Bridge National Monument
3	Last Chance Creek
4	Little Valley Creek
5	Wahweap (NPS Maintenance Compound)
6	On road to Antelope Point
7	Lee's Ferry Ranger Station

1/ Locations noted on topographic map with blue dots.

APPENDIX B

Vegetation Plot Locations[1/]

Plot Number	Location
1	At confluence of San Juan and Colorado Rivers (moor in bay to right, walk up shallow draw to cliffs. Plot under overhang and around spring)
2	Rainbow Bridge National Monument (In end of box canyon to left just before reaching arch)
3	Grotto Canyon (up canyon to small spring, approximately one mile)
4	Navajo Canyon (up canyon, by boat, to sand beach on west side, then up canyon wall)
5	Smoky Mountain (along road on top of mountain)

1/ Locations noted on topographic map with green dots.

Appendix C

Plant species photographed on vegetation observation plots on the Glen Canyon National Recreation Area and Bureau of Land Management, Kanab District Lands in the vicinity of Lake Powell.

LOCATION	SCIENTIFIC NAME	COMMON NAME
Plot #1 - San Juan Junction	Quercus gambelii	Gambel oak
	Rhus trilobata	Squawbush
	Fraxinus anomala	Singleleaf ash
	Ephedra spp.	Brigham tea
	Atriplex spp.	Shadscale
	Berberis fremontii	Desert holly
	Prunus virginiana	Choke cherry
	Celtis reticulata	Hackberry
	Shepherdia rotundifolia	Buffaloberry
	Adiantum capillus-veneris	Maidenhair Fern
Plot #2 - Rainbow Bridge National Monument	Toxicodendron radicans	Poison ivy
	Celtis occidentalis	Hackberry
	Quercus gambelii	Gambel oak
	Salix spp.	Willow
	Shepherdia rotundifolia	Buffaloberry
	Prunus virginiana	Choke cherry
	Cercis occidentalis	Redbud
	Rhus trilobata	Squawbush
	Populus fremontii	Fremont cottonwood
	Adiantum capillus-veneris	Maidenhair Fern
Plot #3 - Grotto Canyon	Prunus virginiana	Choke cherry
	Populus fremontii	Fremont cottonwood
	Celtis occidentalis	Hackberry
	Rhus trilobata	Squawbush
	Salix spp.	Willow
	Shepherdia rotundifolia	Buffaloberry
	Amelanchier utahensis	Utah serviceberry

Appendix C

LOCATION	SCIENTIFIC NAME	COMMON NAME
Plot #4 - Navajo Canyon	*Fraxinus anomala*	Singleleaf ash
	Rhus trilobata	Squawbush
	Clematis spp.	Virgin's Bower
Plot #5 - Smoky Mountain	*Pinus edulis*	Pinyon pine
	Rhus trilobata	Squawbush
	Ephedra spp.	Brigham tea
	Juniperus utahensis	Utah juniper
	Shepherdia rotundifolia	Buffaloberry
	Amelanchier utahensis	Utah serviceberry
	Symphoricarpos spp.	Snowberry
	Cowania mexicana	Cliffrose
	Artemisia tridentata	Big Sagebrush
	Atriplex spp.	Shadscale
	Gutierrezia sarothrae	Snakeweed
	Eurotia lanata	Winterfat
	Sphaeralcea spp.	Globe Mallow
	Atriplex canescens	Fourwing Saltbush
	Chrysothamnus nauseous	Rabbitbrush
	Lycium andersonii	Matrimony vine
	Grayia spinosa	Spiny hopsage
	Coleogyne ramosissima	Blackbrush
	Fraxinus anomala	Singleleaf ash
	Berberis fremontii	Desert holly

Appendix D

Photographs of some representative vegetation from vegetation observation plots. Species, dates, and locations noted.

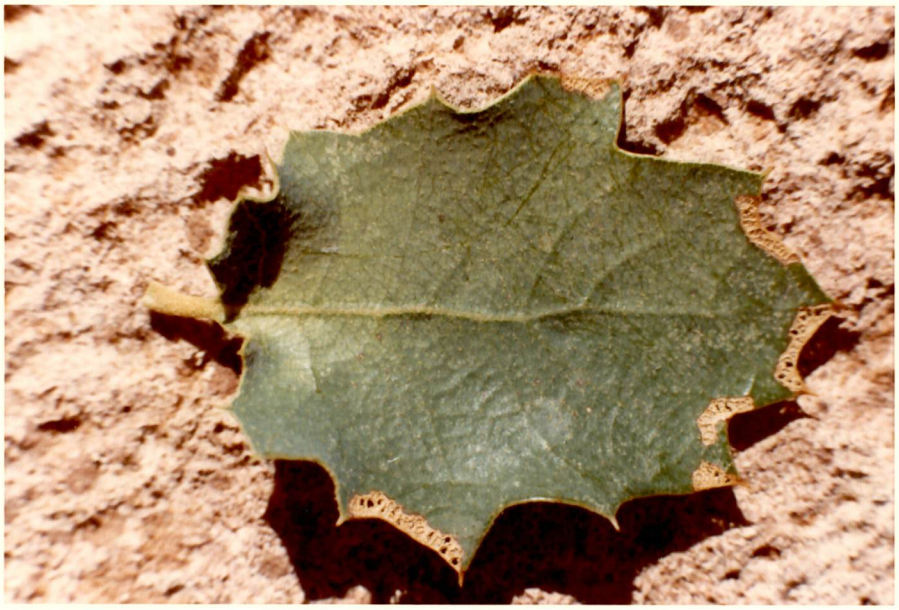


Figure 1. Desert holly, Berberis fremontii. Plot #1. San Juan Junction, June 1974. Upper leaf surface.

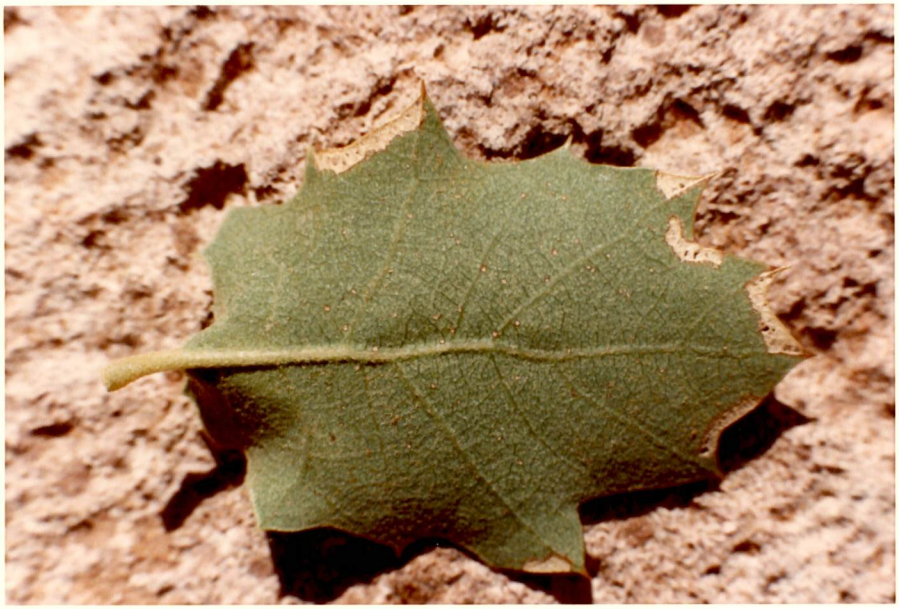


Figure 2. Desert holly. Berberis fremontii. Plot #1. San Juan Junction, June 1974. Lower leaf surface.

Figure 3. Desert holly. Berberis fremontii. Plot #1. San Juan Junction, September 1974. Upper leaf surface.

Figure 4. Desert holly. Berberis fremontii. Plot #1. San Juan Junction, September 1974. Lower leaf surface.

Figure 5. Redbud. Cercis canadensis. Plot #2. Rainbow Bridge National Monument, June 1974. Upper leaf surface.

Figure 6. Redbud. Cercis canadensis. Plot #2. Rainbow Bridge National Monument, September 1974. Lower leaf surface.

Figure 7. Fremont poplar. Populus fremontii. Plot #2. Rainbow Bridge National Monument, June 1974. Upper leaf surface.

Figure 8. Fremont poplar. Populus fremontii. Plot #2. Rainbow Bridge National Monument, September 1974. Upper leaf surface.

Figure 9. Buffaloberry. Shepardia rotundifolia. Plot #3. Grotto Canyon, June 1974. Upper leaf surface.

Figure 10. Buffaloberry. Shepardia rotundifolia. Plot #3. Grotto Canyon, September 1974. Upper and lower leaf surface.

Figure 11. Singleleaf ash. Fraxinus anomala. Plot #4. Navajo Canyon, June 1974. Upper leaf surface.

Figure 12. Singleleaf ash. Fraxinus anomala. Plot #4. Navajo Canyon, September 1974. Upper leaf surface.

Figure 13. Blackbrush. Coleogyne ramosissima. Plot #5. Smoky Mountain, June 1974. Twig and leaves.

Figure 14. Blackbrush. Coleogyne ramosissima. Plot #5. Smoky Mountain, September 1974. Twigs and leaves.

Figure 15. Pinyon pine. Pinus edulis. Plot #5. Smoky Mountain, June 1974. Needles.

Figure 16. Pinyon pine. Pinus edulis. Plot #5. Smoky Mountain, September 1974. Needles.

The Navajo Generating Station, Page, Arizona

GC 1

#1

GLEN CANYON NATIONAL RECREATION AREA

GLEN CANYON NATIONAL RECREATION AREA

NATURAL BRIDGES NATIONAL MONUMENT

MONUMENT

COLORADO

RIVER

WILSON MESA

THE RINCON

IRON TOP MESA

FORTYMILE RIDGE

GOOSE NECK

GOOSE HOPE MESA

TICABOO MESA

COAL BED MESA

CLAY POINT

DESERT

GULCH

CANYON

CLIFFS

HOUSE

FLAT

MESA

POINT

BENCH

SPRING

CREEK

WASH

BLANDING 48 MI

T 41 S

T 40 S

T 39 S

T 38 S

T 37 S

T 36 S

T 35 S

15'

30'

45'

BLM 5

BLM 6

BLM 4

#5

BLM 3

#5

GC 3

GC 4

#1

GC 1

ESCALANTE PETRIFIED FOREST STATE PARK

Escalante

Escalante Substation

Wide Hollow Res

Escalante River

Cherry Creek

Cherry Creek Mine

Dark Canyon Mine

Main Canyon

Radio Tower

Radio Facility

Pine Lake

BARNEY TOP 10450

TABLE CLIFF 10300

PLATEAU

Garden Spr

Paradise Spr

Upper Valley Guard Station

Cabins

Fowell Pt 10198

Shakespeare Arbor

Oil well

Willow Creek

Canyon

Little Valley Wash

Little Valley

Ranch

Rock Spr

CANAAN PEAK 9235

Horse Spr

Horse

Henrieville Spr

Henrieville

Henrieville Creek

Little Creek

Sawmill

Mad Spr

Trail

Death Ridge Res

Right Hand

Canen Spr

Bull Flat

Warnbuck Creek

Dry Valley Creek

Wigwag

Round Valley

Corral

Rock Spr

Headquarters Springs

Blue Wash

Slickrock Valley

Butler Valley

Cabin

Round Valley Seep

Hackberry Canyon

Upper Deer Valley

Rocky

Tibbet Canyon

Deer Range Canyon

CALICO PK

Dem

Parta Mtn

Sand Gulch

Fiftymile Mountain

Coyote Creek

Wahweap

Nipple Spring

Tibbet Spring

South Branch Creek

Smokey Hollow

Worm

Nipple Bench

Paradise Canyon

Escalante Canyon

Stickrock Water Spr

Slickrock Canyon

Hardhead Water Spr

Collet

Collet Canyon

Fence Canyon

Concave Rock

Sunset Flat

Early Weed Bench

Scorpion Gulch

Cat Pasture

Corral 5045

Sit Down Bench

Chance

Allen Dump

Corral

Barney Res

Seep Flat

Halfway Wash

Harris Wash

Ted Brakes

Tenmile Spr

Tenmile Flat

Ford

Big Spencer Flats

Silver Falls Bench

Silver Falls Creek

Wolverine Bench

Wolverine Creek

Little Bowns Bench

BIG BOWN BENCH

COLT MESA

Jackass Spring

Thompson Seep

Clay Seep

Butt Canyon

Deer Point

BIG THOMSON MESA

CLAY

Fourmile Bench

PURPLE HILLS

Baker Bench

East Baker Bench

East Meadz

Middle Meadz Canyon

Holl Divide

Fiftymile Creek

Fiftymile Point

Fiftymile Ridge

Fiftymile Mountain

Fiftymile Cliffs

Fiftymile Bench

Pollywog Bench

Hole in Rock

Flewellyn Gulch

Cottonwood Canyon

Spencer Point

Navajo Point

Navajo Valley

Coyote Gulch

Fence Canyon

Cow Canyon

Jacks Canyon

Gold Canyon

Escalante

Oil Seep Spr

Willow Creek

Gregory Natural Bridge

Davis Gulch

Twentyone Mile Wash

Twentyone Mile Canyon

Middle Mesa

Rocky

Water

Cabin

Oil

Spr

Tank

Can

Creek

Canyon

Wash

Mesa

Point

Bench

Gulch

Ridge

Cliffs

Mountain

Plateau

Basin

Valley

Flat

Hollow

Butte

Divide

Arch

Meadz

Pollywog

Fiftymile

Twentyone Mile

Escalante Canyon

Escalante Rim

Straight Cliffs

Kaiparowits Plateau

Kaiparowits Basin

Cockscomb

Jack Riggs Bench

Buchan Plains

Nipple Bench

Fiftymile Mountain

Glen Canyon National Recreation Area

Grand Staircase-Escalante National Monument

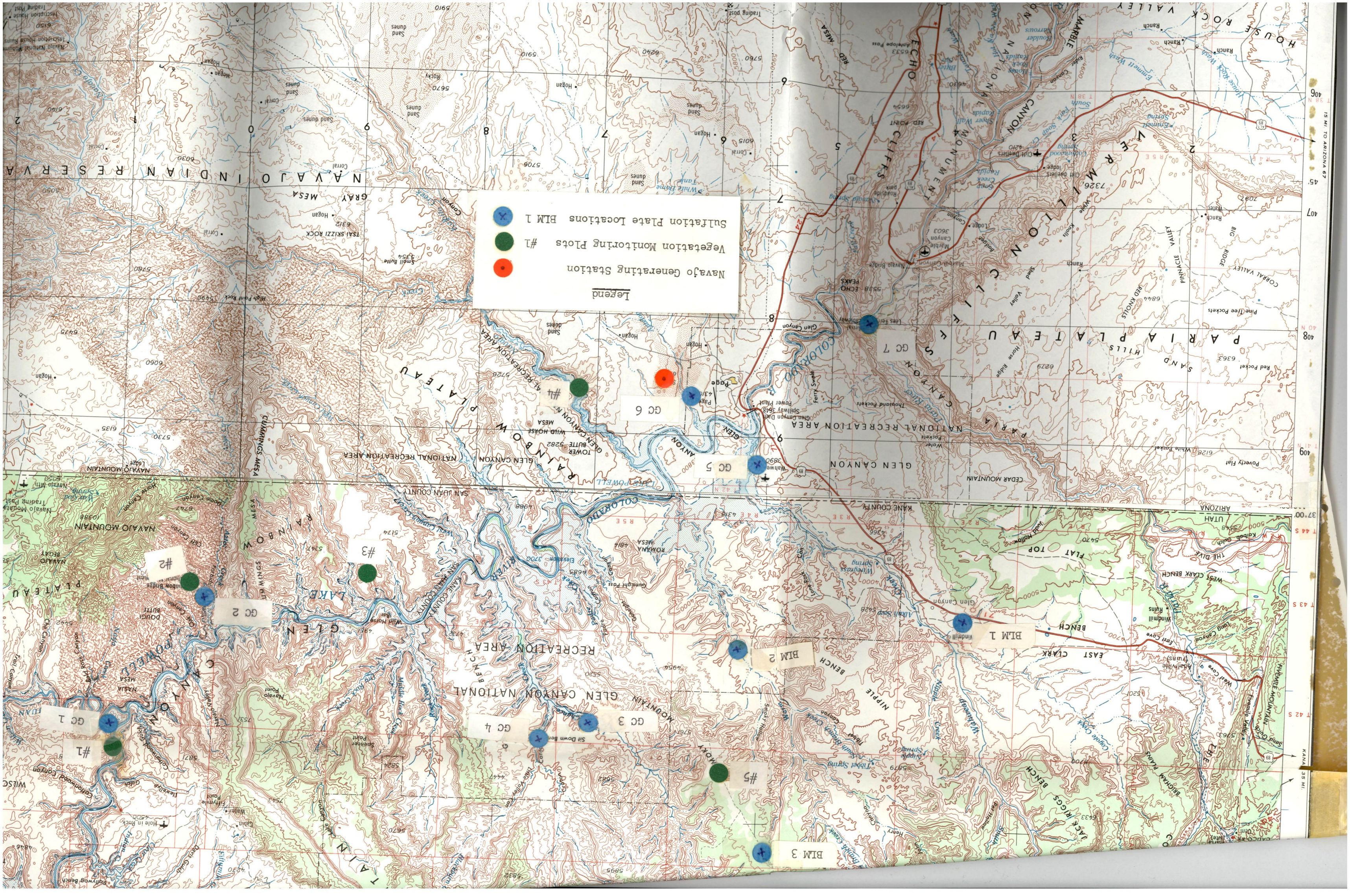
GARFIELD COUNTY

KANE COUNTY

CANNONVILLE 3 MI.

KANAB 35 MI.

#1
GC 1
GC 2
#2
#3
WILSON MESA
NAVAJO INDIAN RESERVATION
NAVAJO MOUNTAIN
NAVAJO MOUNTAIN Lodge
Navajo Mountain Trading Post
Navajo Mtn
NASJA MESA
DOUGI BUTTE
Hawkeye Natural Bridge
Rainbow Bridge National Monument
Wild Horse Bar
Navajo Point
Spencer Point
Fiftymile Point
Hole in Rock
Cabin
Water
Pollywog Bench
THE RINCON
Great Bend
Johnnies Hole
NOKAI DOME
Nancus Foot
Whirlwind Mine
Piute Farms
Farmhouse Gulch
MONITOR BUTTE
MONUMENT
Rocky
Warren Trail
Douglas Wash
Sand dunes
Cedar Spr
Res
ORGAN ROCK
JACOBS MONUMENT
TRAIN ROCK
HOLIDAY MESA
HOSKINNINI MESA
EAGLE MESA
6725 Saddleback
Monument Valley
Goulding
Big Indian
SENTINEL MESA
Stagecoach Wash
Eagle Rock Wash
Monument Wash
Mitchell Butte Wash
Train Rock Wash
Oljeto
Oljeto Wash
OLJETO MESA
VALLEY
THUMB ROCK
NAVAJO BEGAY
PLATEAU
GLEN CANYON
LAKE POWELL
COLORADO RIVER
San Juan River
Navajo Creek
Rainbow Creek
Cliff Canyon
Dome Canyon
Horse Canyon
Jacrabbit Canyon
Warm Spring Canyon
Trail Canyon
Piute Creek
Nasja Creek
Middle Rock Creek
Dry Rock Creek
Cottonwood Canyon
Clay Hill Crossing
Davis Gulch
Fillymile Gulch
Hewelluh Gulch
Cohenwood Gulch
Navajo Valley
Tsegi Canyon
Kane County
San Juan County
Utah
Arizona
Navajo County
Coconino County
Apache County
NATIONAL RECREATION AREA
CUMMINGS MESA
Hogan
Corral
Sand dunes
Rocky
Cliff dwelling
Natural arch
Pueblo site
Natural arches
Mystery Valley
House of Hands Cave
Echo Cave Ruins
Natural bridge
Sand Springs
Cyprus
Water
Trading post
Navajo National Monument
Inscription House Ruins
Inscription House Trading Post
Betatakin Ruins
Keet Seel Ruins
Keet Seel Canyon
Tsegi Canyon
Marsh Pass
Kayenta
Laguna Cr
Laguna Creek
Little Salt Canyon
Degashbito Wash
Dzahaltsoh Canyon
Nokai Canyon
Piute Canyon
Castle Canyon
Moonlight Creek
Parrish Creek
Yellow Wash
Adohchiiyahi Can
Cottonwood Wash
Tsaiskizzi Creek
Middle Rock Creek
Dry Rock Creek
Navajo Creek
Chinle Creek
Canyon
BIG POINT
BOOT MESA
SKELETON MESA
ZILNEZ MESA
GRAY MESA
PIUTE MESA
NOKAI MESA
LONG CANYON
NO MANS MESA
COPPER MESA
MONITOR MESA
WEATHERILL MESA
HUNTS MESA
TYENDE MESA
AGATHLA PEAK
GRAY HILLS
OWL ROCK
HALF DOME
CHAISTLA BUTTE
CHURCH ROCK
BABY ROCKS MESA
LITTLE CAPITAN VALLEY
Comb Ridge
EL CAPITAN FLAT
El Capitan Wash
HAT ROCK
MITCHELL BUTTE
MITCHELL MESA
MERRICK BUTTE
SPEARHEAD MESA
Laguna Cr
Tsaiskizzi Creek
Kayenta
Tsegi Canyon
Marsh Pass
Trading post
Navajo National Monument
Keet Seel Ruins
Betatakin Ruins
Inscription House Ruins
Inscription House Trading Post
Hogan
Corral
Sand dunes
Rocky
Cliff dwelling
Natural arch
Pueblo site
Natural arches
Mystery Valley
House of Hands Cave
Echo Cave Ruins
Natural bridge
Sand Springs
Cyprus
Water
Trading post
Navajo National Monument
Inscription House Ruins
Inscription House Trading Post
Betatakin Ruins
Keet Seel Ruins
Keet Seel Canyon
Tsegi Canyon
Marsh Pass
Kayenta
Laguna Cr
Laguna Creek
Little Salt Canyon
Degashbito Wash
Dzahaltsoh Canyon
Nokai Canyon
Piute Canyon
Castle Canyon
Moonlight Creek
Parrish Creek
Yellow Wash
Adohchiiyahi Can
Cottonwood Wash
Tsaiskizzi Creek
Middle Rock Creek
Dry Rock Creek
Navajo Creek
Chinle Creek
Canyon
BIG POINT
BOOT MESA
SKELETON MESA
ZILNEZ MESA
GRAY MESA
PIUTE MESA
NOKAI MESA
LONG CANYON
NO MANS MESA
COPPER MESA
MONITOR MESA
WEATHERILL MESA
HUNTS MESA
TYENDE MESA
AGATHLA PEAK
GRAY HILLS
OWL ROCK
HALF DOME
CHAISTLA BUTTE
CHURCH ROCK
BABY ROCKS MESA
LITTLE CAPITAN VALLEY
Comb Ridge
EL CAPITAN FLAT
El Capitan Wash
HAT ROCK
MITCHELL BUTTE
MITCHELL MESA
MERRICK BUTTE
SPEARHEAD MESA
Laguna Cr
Tsaiskizzi Creek
Kayenta
T 40 S
T 41 S
T 42 S
T 43 S
15'
37°00'
410000m N.
MEXICAN HAT 11 MI.
409
408
407
406
45'


Legend
Navajo Generating Station
Vegetation Monitoring Plots #1
Sulfation Plate Locations BLM 1
GC 1
GC 2
GC 3
GC 4
GC 5
GC 6
GC 7
#1
#2
#3
#4
#5
BLM 1
BLM 2
BLM 3
NAVAJO INDIAN RESERVA
GRAY MESA
PARIA PLATEAU
GLEN CANYON
COLORADO
ECHO CLIFFS
MARBLE CANYON
VERMILION CLIFFS
HOUSE ROCK VALLEY
PARIA
CEDAR MOUNTAIN
NAVAJO MOUNTAIN
KANE COUNTY
ARIZONA
UTAH
15 MI TO ARIZONA 67
35 MI